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(54) **THIN FILM TRANSISTOR SUBSTRATE HAVING ELECTROSTATIC PROTECTION STRUCTURE AND LIQUID CRYSTAL DISPLAY PANEL**

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(58) **Field of Classification Search**
None
See application file for complete search history.

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(57) **ABSTRACT**
A thin film transistor (TFT) substrate optimized for protection against the build up of static electricity defines a display area and a non-display area surrounding the display area. The TFT substrate includes a substrate and an electrostatic protection structure on the substrate and in the non-display area. The electrostatic protection structure includes a transparent conductive layer and a discharge metal layer on the transparent conductive layer. The discharge metal layer partially overlaps with the transparent conductive layer. The discharge metal layer is in direct contact with the transparent conductive layer. The transparent conductive layer has a width that is greater than a width of the discharge metal layer.

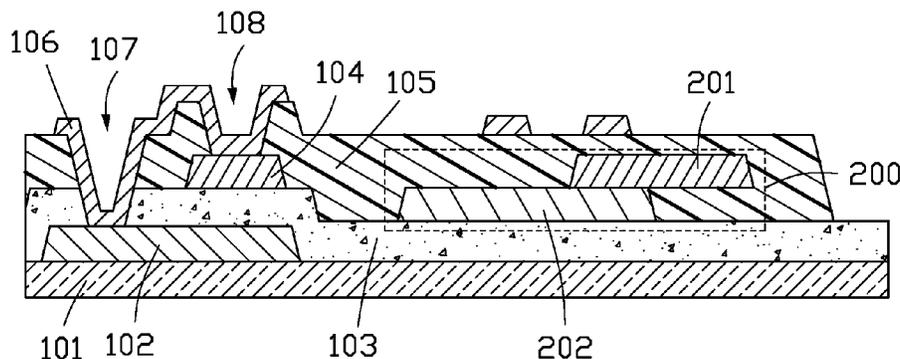
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H01L 27/02 (2006.01)
G02F 1/1333 (2006.01)
G02F 1/1368 (2006.01)
G02F 1/1335 (2006.01)

16 Claims, 4 Drawing Sheets



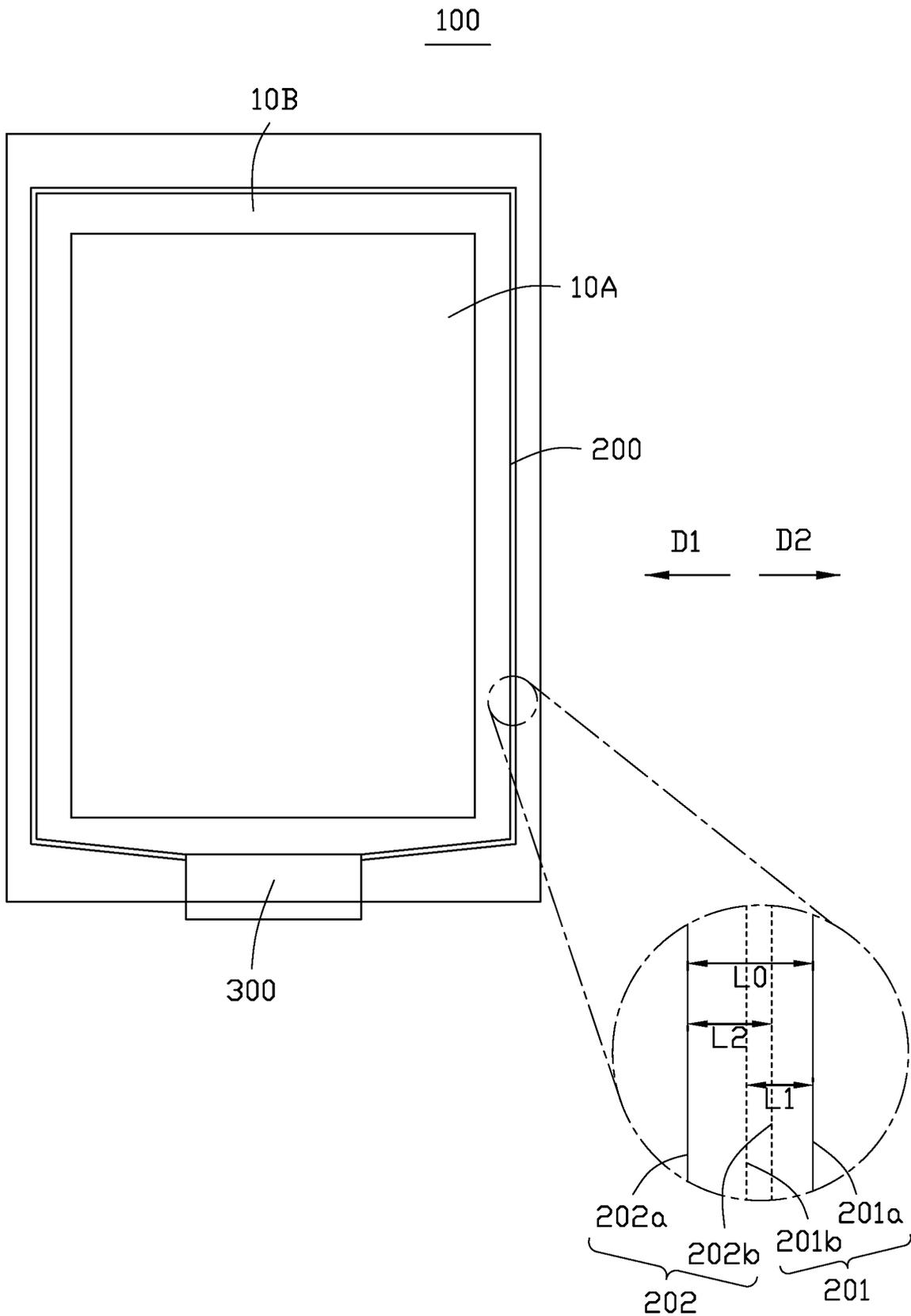


FIG. 1

100

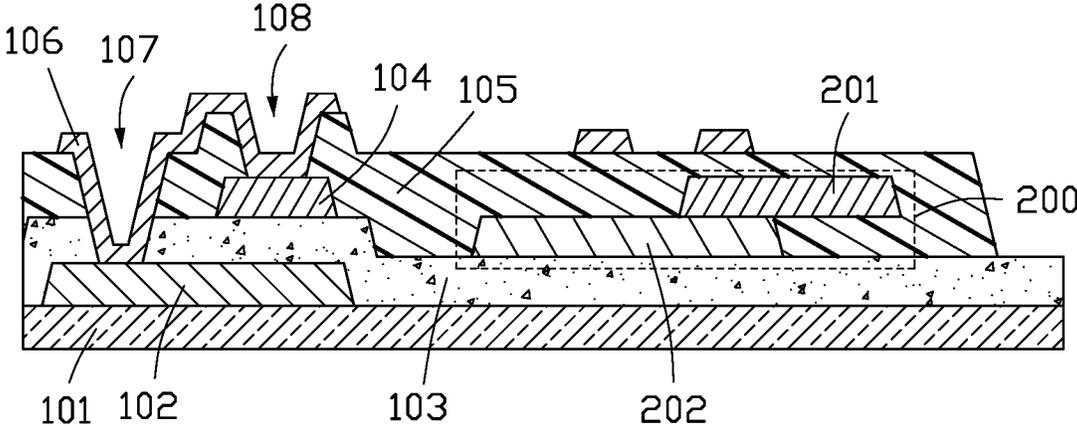


FIG. 2

400

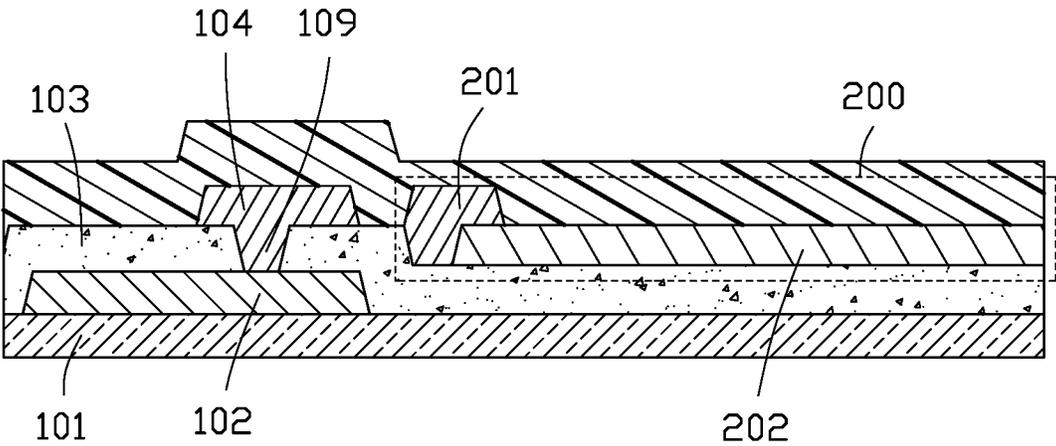


FIG. 3

500

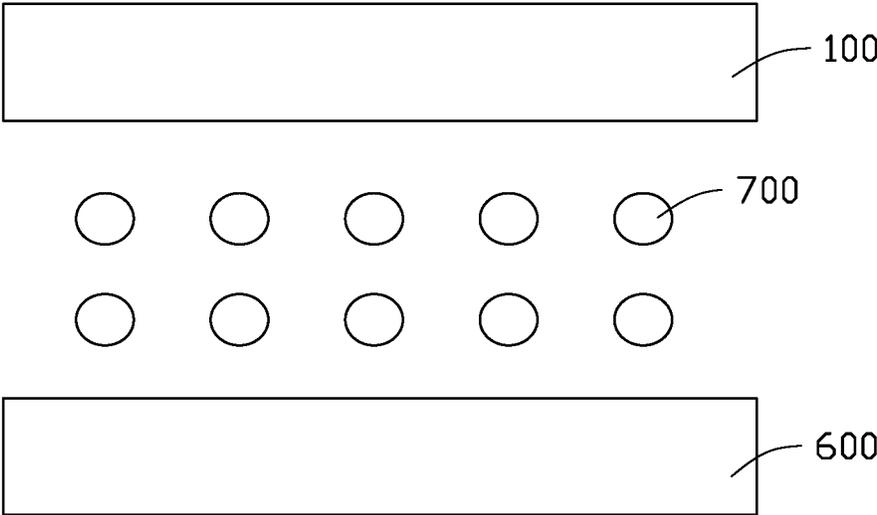


FIG. 4

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**THIN FILM TRANSISTOR SUBSTRATE
HAVING ELECTROSTATIC PROTECTION
STRUCTURE AND LIQUID CRYSTAL
DISPLAY PANEL**

FIELD

The subject matter herein generally relates to a thin film transistor (TFT) substrate and a liquid crystal display panel having the TFT substrate.

BACKGROUND

Static electricity is generated during the preparation of a display panel. If the static electricity is accumulated inside the display panel and has no way to be conducted out of the display panel, then the static electricity discharges within the panel, thereby damaging the internal structure of the display panel.

Therefore, there is room for improvement in the art.

BRIEF DESCRIPTION OF THE DRAWINGS

Implementations of the present technology will now be described, by way of embodiments only, with reference to the attached figures.

FIG. 1 is a top view of a TFT substrate with an electrostatic protection structure according to an embodiment of the present disclosure.

FIG. 2 is a cross-sectional view of a non-display area of the TFT substrate according to a first embodiment of the present disclosure.

FIG. 3 is a cross-sectional view of a non-display area of a TFT substrate according to a second embodiment of the present disclosure.

FIG. 4 is a cross-sectional view of a liquid crystal display panel according to an embodiment of the present disclosure.

DETAILED DESCRIPTION

It will be appreciated that for simplicity and clarity of illustration, where appropriate, reference numerals have been repeated among the different figures to indicate corresponding or analogous elements. In addition, numerous specific details are set forth in order to provide a thorough understanding of the embodiments described herein. However, it will be understood by those of ordinary skill in the art that the embodiments described herein may be practiced without these specific details. In other instances, methods, procedures, and components have not been described in detail so as not to obscure the related relevant feature being described. Also, the description is not to be considered as limiting the scope of the embodiments described herein. The drawings are not necessarily to scale and the proportions of certain parts may be exaggerated to better illustrate details and features of the present disclosure.

The term “coupled” is defined as coupled, whether directly or indirectly through intervening components, and is not necessarily limited to physical connections. The connection can be such that the objects are permanently coupled or releasably coupled. The term “comprising” when utilized, means “including, but not necessarily limited to”; it specifically indicates open-ended inclusion or membership in the so-described combination, group, series, and the like.

FIG. 1 illustrates a TFT substrate **100** of an embodiment. The TFT substrate **100** includes a display area **10A** and a non-display area **10B** surrounding the display area **10A**. The

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TFT substrate **100** includes an electrostatic protection structure **200** and a printed circuit board **300**, both being in the non-display area **10B**. The electrostatic protection structure **200** extends around the display area **10A** and is electrically connected to the printed circuit board **300**. The printed circuit board **300** provides electrical signals for the TFT substrate **100**. In this embodiment, the printed circuit board **300** can also provide a grounding point required in the electrostatic discharge process of the electrostatic protection structure **200**, so static electricity can be effectively discharged by the electrostatic protection structure **200**. In this embodiment, the printed circuit board **300** may be a flexible printed circuit board (FPC).

As shown in FIG. 1 and FIG. 2, the electrostatic protection structure **200** includes a transparent conductive layer **202** and a discharge metal layer **201** on the transparent conductive layer **202**. The discharge metal layer **201** partially overlaps with the transparent conductive layer **202**. The discharge metal layer **201** is in direct contact with and electrically connected to the transparent conductive layer **202**. The transparent conductive layer **202** and the discharge metal layer **201** extend in opposite directions from an overlapped portion of the transparent conductive layer **202** and the discharge metal layer **201**, and an extended width of the transparent conductive layer **202** is greater than an extended width of the discharge metal layer **201**. The transparent conductive layer **202** has a width that is greater than a width of the discharge metal layer **201**. Both the discharge metal layer **201** and the transparent conductive layer **202** extend around the display area.

As shown in FIG. 2, the TFT substrate **100** includes a substrate **101**, a first metal layer **102** on the substrate **101**, a first insulating layer **103** on the substrate **101** and covering the first metal layer **102**, a second metal layer **104** on the first insulating layer **103**, and a second insulating layer **105** on the first insulating layer **103** and covering the second metal layer **104**. FIG. 2 only shows the non-display area **10B** of the TFT substrate **100**, in reality the first metal layer **102**, the second metal layer **104**, the first insulating layer **103**, and the second insulating layer **105** also extend to the display area **10A**.

In this embodiment, the electrostatic protection structure **200** is located on the first insulating layer **103**. The transparent conductive layer **202** is located on the first insulating layer **103**. The discharge metal layer **201** and the second metal layer **104** are formed by patterning a single metal layer. The second insulating layer **105** covers the second metal layer **104**, the transparent conductive layer **202**, and the discharge metal layer **201**. The electrostatic protection structure **200** conducts the static electricity to the grounding point of the printed circuit board **300**. For example, the electrostatic protection structure **200** can be electrically connected to the pixel units in the display area **10A** of the TFT substrate **100** to discharge static electricity in the pixel units, thereby ensuring that the TFT substrate **100** operates normally.

Further referring to FIG. 1, the transparent conductive layer **202** extends in a direction **D1** from an overlapped portion of the transparent conductive layer **202** and the discharge metal layer **201**, and the discharge metal layer **201** extends in a direction **D2** from an overlapped portion of the transparent conductive layer **202** and the discharge metal layer **201**. The directions **D1** and **D2** are opposite to each other. The transparent conductive layer **202** includes a first side **202a** adjacent to the display area **10A** and a second side **202b** away from the display area **10A**. A distance between the first side **202a** and the second **202b** is a width **L2** of the

transparent conductive layer **202**. The discharge metal layer **201** includes a first side **201b** adjacent to the display area **10A** and a second side **201a** away from the display area **10A**. A distance between the first side **201a** and the second side **201b** is a width **L1** of the discharge metal layer **201**. A distance between the second side **201a** and the first side **202a** is a total width **L0** of the transparent conductive layer **202** and the discharge metal layer **201**. The width **L0** is greater than the width **L1** of the discharge metal layer **201** or the width **L2** of the transparent conductive layer **202**. The width **L2** is greater than the width **L1**. For better panel design, the greater the width of **L2** over **L1** the better, which is beneficial to use the transparent conductive layer **202** to discharge static electricity.

A conventional electrostatic discharging structure increases a path of electrostatic discharge by widening the metal lines for electrostatic discharge. However, widening of the metal lines for electrostatic discharge results in increasing opacity of the metal lines, and thereby insufficient curing of the sealant on the panel frame becomes more likely. In this embodiment, the electrostatic protection structure **200** is used for electrostatic discharge. That is, the transparent conductive layer **202** is partially overlapped with and electrically connected to the discharge metal layer **201**, and the transparent conductive layer **202** is used for electrostatic discharge. In this disclosure, the transparent conductive layer **202** effectively widens the functioning width of the electrostatic protection structure **200** without widening parts of the discharge metal layer **201**, avoiding the risk of insufficient curing of the sealant on the panel frame.

In this embodiment, the transparent conductive layer **202** is made of indium tin oxide, zinc oxide, or aluminum-doped zinc oxide. It can be understood that the material of the transparent conductive layer **202** is not limited to indium tin oxide, zinc oxide, zinc oxide, and aluminum-doped zinc oxide. The substrate **101** may be a transparent glass substrate.

In this embodiment, the TFT substrate **100** further includes a plurality of TFTs (not shown) on the substrate **101** and located in the display area **10A**. The discharge metal layer **201** and functional electrodes of the TFTs may be formed by patterning a single metal layer. In this embodiment, the functional electrodes may include source electrodes and drain electrodes of the TFTs. FIG. 2 only shows a part of the second metal layer **104** located in the non-display area **10B**, in fact the second metal layer **104** also extends to the display area **10A**, so that a part of the second metal layer **104** forms source electrodes (not shown) and drain electrodes (not shown) of the TFTs.

Further referring to FIG. 2, the TFT substrate **100** further includes a conductive connection layer **106**. A first opening **107** is defined in the first insulating layer **103** and the second insulating layer **105** to expose the first metal layer **102**. A second opening **108** is defined in the second insulating layer **105** to expose the second metal layer **104**. The conductive connection layer **106** is formed on the second insulating layer **105** and extends into the first opening **107** and the second opening **108**, realizing electrical connections between the first metal layer **102** and the second metal layer **104**.

In this embodiment, the conductive connection layer **106** may be a transparent conductive layer. The conductive connection layer **106** is made of indium tin oxide, zinc oxide, or aluminum-doped zinc oxide, but it is not limited thereto.

FIG. 3 illustrates a TFT substrate **400** of a second embodiment. The difference between the TFT substrate **400** and the

TFT substrate **100** of the first embodiment of FIG. 2 is that the first metal layer **102** and the second metal layer **104** in the TFT substrate **400** are not electrically connected by the conductive connection layer **106**, the first opening **107**, and the second opening **108**.

In this example, the TFT substrate **400** includes a substrate **101**, a first metal layer **102** on the substrate **101**, a first insulating layer **103** on the substrate **101** and covering the first metal layer **102**, a second metal layer **104** on the first insulating layer **103**, and a second insulating layer **105** on the first insulating layer **103** and covering the second metal layer **104**. An opening **109** is defined in the first insulating layer **103** to expose the first metal layer **102**, and the second metal layer **104** and the first metal layer **102** are electrically connected by the opening **109**.

The TFT substrate **400** and the TFT substrate **100** are TFT substrates with different manufacturing processes. The electrostatic protection structure **200** is applicable to the TFT substrate **400** and the TFT substrate **100**, and applicable to other TFT substrates.

FIG. 4 illustrates a liquid crystal display panel **500** according to an embodiment of the present disclosure. The liquid crystal display panel **500** includes the TFT substrate **100**, a color filter substrate **600**, and a liquid crystal layer **700** between the TFT substrate **100** and the color filter substrate **600**.

The liquid crystal display panel **500** is in an electronic device that needs a display screen, such as mobile phone, mobile TV, smart phone, BLUETOOTH devices, wireless email receiver, handheld or portable computer, mini laptop, notebook computer, smart book, tablet computer, printer, copier, scanner, fax machine, GPS receiver/navigator, camera, digital media player, camcorder, games controlling panel, watch, clock, calculator, TV monitor, flat panel display, e-reading device (e.g. e-readers), mobile health device, computer monitor, car dashboard display (including odometer display, speedometer display, etc.), cockpit control and/or display, camera landscape display (e.g., rear-view camera display in vehicle), electronic photograph, electronic billboard or sign, projector, refrigerator, scrubber, dryer, scrubber/dryer device, aesthetic structure (for example, an image displaying a piece of jewelry or clothing), but is not limited to these.

The electrostatic protection structure **200** is configured to discharge static electricity. The transparent conductive layer **202** is partially overlapped with and electrically connected to the discharge metal layer **201**, and the transparent conductive layer **202** is used for electrostatic discharge. In this way, the transparent conductive layer **202** creates additional width of the electrostatic protection structure **200** without widening the opaque discharge metal layer **201**, thereby avoiding insufficient curing of the sealant on the panel frame.

It is to be understood, even though information and advantages of the present embodiments have been set forth in the foregoing description, together with details of the structures and functions of the present embodiments, the disclosure is illustrative only; changes may be made in detail, especially in matters of shape, size, and arrangement of parts within the principles of the present embodiments to the full extent indicated by the plain meaning of the terms in which the appended claims are expressed.

What is claimed is:

1. A thin film transistor (TFT) substrate, the TFT substrate defining a display area and a non-display area surrounding the display area, comprising:

a substrate;

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an electrostatic protection structure on the substrate and in the non-display area, wherein the electrostatic protection structure comprises a transparent conductive layer and a discharge metal layer on the transparent conductive layer; the discharge metal layer partially overlaps with the transparent conductive layer, the discharge metal layer is in direct contact with the transparent conductive layer; the transparent conductive layer has a width that is greater than a width of the discharge metal layer.

2. The TFT substrate of claim 1, wherein both the discharge metal layer and the transparent conductive layer extend around the display area.

3. The TFT substrate of claim 2, wherein the TFT substrate further comprises a printed circuit board in the non-display area, the electrostatic protection structure extends around the display area and is electrically connected to the printed circuit board.

4. The TFT substrate of claim 1, wherein the TFT substrate further comprises a substrate, a first metal layer on the substrate, a first insulating layer on the substrate and covering the first metal layer, a second metal layer on the first insulating layer, and a second insulating layer on the first insulating layer and covering the second metal layer.

5. The TFT substrate of claim 4, wherein the transparent conductive layer is formed on the first insulating layer, and the discharge metal layer and the second metal layer is defined by patterning a single metal layer; and the second insulating layer covers the transparent conductive layer, the discharge metal layer, and the second metal layer.

6. The TFT substrate of claim 5, wherein the TFT substrate further comprises a plurality of TFTs in the display area, the second metal layer forms function electrodes of the plurality of TFTs.

7. The TFT substrate of claim 5, wherein the TFT substrate further comprises a conductive connection layer; a first opening defined in the first insulating layer and the second insulating layer to expose the first metal layer; a second opening is defined in the second insulating layer to expose the second metal layer; the conductive connection layer is formed on the second insulating layer and extends into the first opening and the second opening to realize electrical connection between the first metal layer and the second metal layer.

8. The TFT substrate of claim 5, wherein an opening is defined in the first insulating layer to expose the first metal layer, and the second metal layer and the first metal layer are electrically connected by the opening.

9. A liquid crystal display panel, comprising:
 a color filter substrate;
 a thin film transistor (TFT) substrate, and
 a liquid crystal layer between the TFT substrate and the color filter substrate;

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the TFT substrate defining a display area and a non-display area surrounding the display area, comprising:
 a substrate;
 an electrostatic protection structure on the substrate and in the non-display area,

wherein the electrostatic protection structure comprises a transparent conductive layer and a discharge metal layer on the transparent conductive layer;

the discharge metal layer partially overlaps with the transparent conductive layer, the discharge metal layer is in direct contact with the transparent conductive layer; the transparent conductive layer has a width that is greater than a width of the discharge metal layer.

10. The liquid crystal display panel of claim 9, wherein both the discharge metal layer and the transparent conductive layer extend around the display area.

11. The liquid crystal display panel of claim 10, wherein the TFT substrate further comprises a printed circuit board in the non-display area, the electrostatic protection structure extends around the display area and is electrically connected to the printed circuit board.

12. The liquid crystal display panel of claim 9, wherein the TFT substrate further comprises a substrate, a first metal layer on the substrate, a first insulating layer on the substrate and covering the first metal layer, a second metal layer on the first insulating layer, and a second insulating layer on the first insulating layer and covering the second metal layer.

13. The liquid crystal display panel of claim 12, wherein the transparent conductive layer is formed on the first insulating layer, and the discharge metal layer and the second metal layer are defined by patterning a single metal layer; and the second insulating layer covers the transparent conductive layer, the discharge metal layer, and the second metal layer.

14. The liquid crystal display panel of claim 13, wherein the TFT substrate further comprises a conductive connection layer; a first opening defined in the first insulating layer and the second insulating layer to expose the first metal layer; a second opening is defined in the second insulating layer to expose the second metal layer; the conductive connection layer is formed on the second insulating layer and extends into the first opening and the second opening to realize electrical connection between the first metal layer and the second metal layer.

15. The liquid crystal display panel of claim 13, wherein an opening is defined in the first insulating layer to expose the first metal layer, and the second metal layer and the first metal layer are electrically connected by the opening.

16. The liquid crystal display panel of claim 9, wherein the TFT substrate further comprises a plurality of TFTs in the display area, the second metal layer forms function electrodes of the plurality of TFTs.

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